

The IN2021_V04 and IN2022_V08 expeditions to the Australian Christmas Island and Cocos (Keeling) Islands Territories.

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Abstract This report contains a list of benthic sampling operations collected by the IN2021_V04 and IN2022_V08 expeditions to the Australian Christmas Island and Cocos (Keeling) Islands Territories

Keywords Indian Ocean Territories, illustrated catalogue, biodiversity, species discovery, deep-sea

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Introduction

The eastern Indian Ocean is an under-explored marine environment that contains numerous seamounts, oceanic ridges, fracture zones and deep abyssal plains. The seamounts are the remains of ancient (120–40 million year old) volcanos that have now mostly subsided hundreds of meters below sea-level. The few exceptions include Christmas Island, the Cocos (Keeling) atolls, and the Muirfield seamount that peaks at only 17 m below sea level. In 2021, the Australian Government recognised the unique biodiversity around these islands by proclaiming two new large marine parks, which together protect an area of 744,069 km².

Australia’s ocean research vessel ‘Investigator’ conducted two biodiversity surveys of the Christmas and Cocos (Keeling) Island Marine Parks (MP) in July 2021 (IN2021_V04) and October 2022 (IN2022_V08) to support park management in Australia’s Indian Ocean Territories (IOT). Both surveys were led by Museums Victoria from Melbourne Australia, collaborating with CSIRO (Australia’s main research agency), the Australian Museum (Sydney), and the Western Australian Museum (Perth). The voyages were funded through CSIRO’s Marine National Facility (MNF), Parks Australia and the Department of Environment’s BushBlitz program.

A goal of the surveys was to sample biodiversity

from a broad range of ecological niches across the seafloor of the IOT, with a conservation-inspired focus on the shallower seamounts and islands. Operational

constraints limited benthic sampling to between 60 and 5000 m.

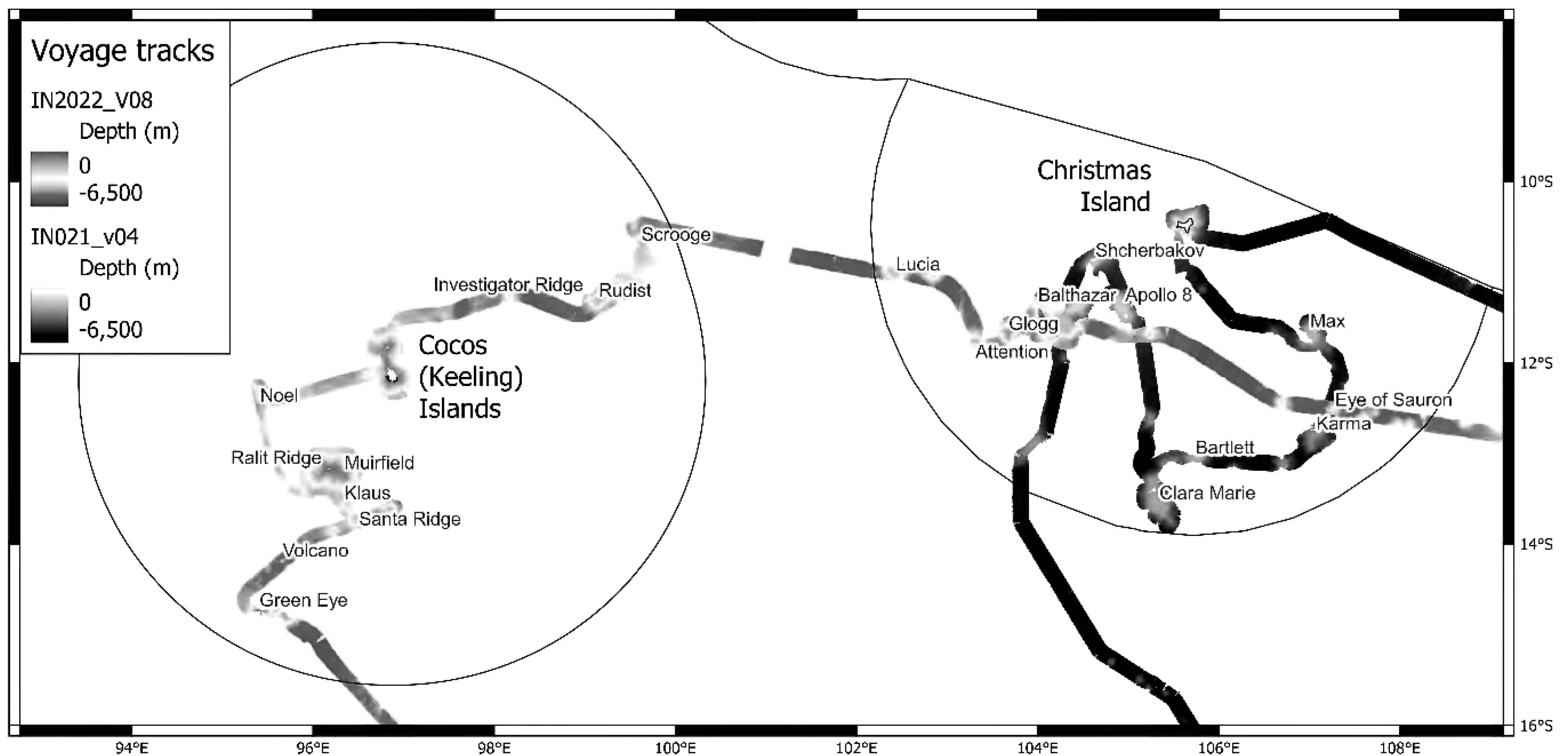


Figure 1. Voyage tracks of the IN2021_V04 and IN2022_V08 expeditions.

Methods

The proposed sampling design followed a spatially-randomised procedure using the R function `quasiSamp()` in the library `MBHDesign` (Foster *et al.*, 2017), based on the seafloor bathymetry in the 2009 AusSeabed raster dataset, clipped to the spatial limits of the two marine parks, which was largely based on satellite gravity readings. Shallower seafloor was emphasised by setting an inclusion probability for each raster pixel to the transformed exponential of the depth/1000. The sampling design was aspirational, and target locations were shifted to more suitable sampling locations at broadly the same depth when multibeam bathymetry and backscatter was obtained. Benthic sampling sites were selected from areas with reasonable sediment cover, either on seamount summits, sediment-draped ridges on seamount flanks, or from the abyssal plain.

The primary benthic sampler was a 4 m (metal) beam trawl, with a mesh size of 12 mm bar in the main net and 10 mm at the cod-end (Lewis, 2010). On the IN2022_V08 voyage, a small 500 mesh “Gandalf” net was attached to the upper surface of the beam trawl net to collect smaller macro-invertebrates. A heavy “Sherman” epibenthic sled (Lewis, 2009), with a 1200 x 600 mm mouth and 12 mm bar mesh co-end, was deployed on rocky seafloor. The IN2021_V04 voy-

age collected 20 beam trawls and 6 epibenthic sleds and the IN2022_V08 voyage collected 40 beam trawls (plus Gandalf) and 6 epibenthic sleds. The Appendix to this report contains a list of benthic biodiversity sampling locations from both IOT voyages, and details and narratives of the voyages can be found in the End-of-Voyage Highlights Reports (O’Hara 2021, 2022).

Results

Initial biodiversity results and conservation assessments are discussed in two park management reports (O’Hara, 2023a,b). Geomorphological and oceanographical results are presented in O’Hara O’Hara (2024b). Catalogues documenting the biodiversity of some key marine invertebrate taxa discovered on these voyages are now available as *Museums Victoria Science Reports* numbers 24–30 (Criscione, 2024; Horowitz, 2024; Hosie, 2024; Kupriyanova *et al.*, 2024; Mah, 2024; Miskelly, 2024; O’Hara, 2024a). Formal description of new species has commenced, with three publications already in press (Flaxman & Kupriyanova, 2024; Kupriyanova & Flaxman, 2024; Mackenzie *et al.*, 2024).

Acknowledgements

This research was supported by a grant of sea time on RV Investigator from the CSIRO Marine National Facility (MNF, <https://ror.org/01mae9353>); and operational support and funding from Australia's Department of Climate Change, Energy, the Environment and Water through their Parks Australia and Bushblitz programs.

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Appendix - Station list

List of benthic sampling operations from the IN2021_V04 and IN2022_V08 expeditions. EBS – ‘Sherman’ epibenthic sled, BT - CSIRO Four Metre Beam Trawl. Latitude and longitude decimal degrees. Depths in metres.

					On Bottom			Off Bottom				
	Survey	Op	Locality	Gear	Date (UTC)	Latitude	Longitude	Depth	Date (UTC)	Latitude	Longitude	Depth
4	IN2021_v04	2	Christmas Island	BT	06/07/2021 14:28	-10.5501	105.7031	1225	06/07/2021 14:45	-10.5418	105.7081	1626
	IN2021_v04	5	Christmas Island	BT	06/07/2021 21:29	-10.5703	105.6896	643	06/07/2021 21:49	-10.5632	105.6939	997
	IN2021_v04	7	Christmas Island	BT	07/07/2021 3:43	-10.5561	105.7642	3200	07/07/2021 4:26	-10.5427	105.7717	3345
	IN2021_v04	9	Christmas Island	BT	07/07/2021 20:00	-10.4364	105.5775	957	07/07/2021 20:19	-10.4364	105.5877	1154
	IN2021_v04	12	Christmas Island	BT	08/07/2021 3:58	-10.3991	105.5948	2000	08/07/2021 4:20	-10.3974	105.6014	2051
	IN2021_v04	13	Christmas Island	BT	08/07/2021 7:15	-10.4247	105.5949	1363	08/07/2021 7:39	-10.4241	105.6013	1501
	IN2021_v04	16	Christmas Island	EBS	08/07/2021 14:46	-10.4298	105.5647	781	08/07/2021 15:08	-10.4278	105.5743	1114
	IN2021_v04	18	Christmas Island	EBS	08/07/2021 18:27	-10.4301	105.537	463	08/07/2021 18:48	-10.4301	105.5471	442
	IN2021_v04	20	Christmas Island	EBS	08/07/2021 22:20	-10.5194	105.5118	427	08/07/2021 22:46	-10.5243	105.514	554
	IN2021_v04	22	Christmas Island	BT	09/07/2021 2:18	-10.5497	105.5331	1388	09/07/2021 2:45	-10.5543	105.536	1533
	IN2021_v04	24	Christmas Island Abyssal	BT	09/07/2021 13:31	-10.9655	105.5637	4764	09/07/2021 14:41	-10.975	105.5962	4766
	IN2021_v04	26	Max Seamount	BT	10/07/2021 11:46	-11.7101	107.0319	1915	10/07/2021 12:42	-11.7153	107.0577	1990
	IN2021_v04	28	Karma Seamount	BT	11/07/2021 2:36	-12.8259	107.0465	2760	11/07/2021 3:16	-12.8338	107.06	2850
	IN2021_v04	31	Clara Marie Seamount	BT	12/07/2021 10:42	-13.5763	105.3274	2189	12/07/2021 11:40	-13.5766	105.3676	2264
	IN2021_v04	33	Clara Marie Seamount	BT	12/07/2021 18:50	-13.702	105.4193	3007	12/07/2021 19:35	-13.7019	105.4466	3100
	IN2021_v04	35	Apollo 8 Seamount	BT	13/07/2021 20:14	-11.4126	104.9421	1285	13/07/2021 21:06	-11.4127	104.9652	1350
	IN2021_v04	37	Apollo 8 Seamount	BT	14/07/2021 1:17	-11.4717	105.004	1640	14/07/2021 2:22	-11.4726	105.0374	1850
	IN2021_v04	40	Shcherbakov Seamount	BT	14/07/2021 18:24	-10.9246	104.6115	1608	14/07/2021 19:12	-10.924	104.6345	1663
	IN2021_v04	42	Shcherbakov Seamount	EBS	15/07/2021 2:36	-10.9682	104.6357	3070	15/07/2021 4:10	-10.9714	104.648	3400
	IN2021_v04	44	Shcherbakov	EBS	15/07/2021 9:29	-10.856	104.7246	1970	15/07/2021 10:09	-10.8539	104.7379	2130
	IN2021_v04	46	Balthazar Seamount	BT	16/07/2021 4:17	-11.4044	104.4403	1237	16/07/2021 5:01	-11.4053	104.4637	1290
	IN2021_v04	48	Balthazar Seamount	BT	16/07/2021 14:27	-11.3741	104.4854	1260	16/07/2021 16:58	-11.3704	104.5038	1347
	IN2021_v04	50	Balthazar Seamount	BT	16/07/2021 21:12	-11.4507	104.502	2289	16/07/2021 21:49	-11.4517	104.5166	2358
	IN2021_v04	52	Balthazar Seamount	BT	17/07/2021 6:24	-11.4907	104.4102	3136	17/07/2021 8:25	-11.4918	104.412	3172
	IN2021_v04	53	Balthazar Seamount	BT	17/07/2021 12:27	-11.5632	104.2838	1554	17/07/2021 13:42	-11.5541	104.3221	1646
	IN2022_v08	103	Balthazar Seamount	BT	06/10/2022 16:29	-11.3592	104.0482	3611	06/10/2022 17:58	-11.3712	104.0578	3510
	IN2022_v08	105	Balthazar Seamount	BT	07/10/2022 5:04	-11.6343	104.1902	2435	07/10/2022 6:01	-11.6612	104.2258	2298
	IN2022_v08	106	Christmas Abyssal	BT	07/10/2022 14:04	-11.6458	103.9613	4908	07/10/2022 15:49	-11.6582	103.9985	4944
	IN2022_v08	108	Glogg Seamount	BT	08/10/2022 5:41	-11.6478	103.6397	1451	08/10/2022 6:26	-11.6645	103.6555	1355
	IN2022_v08	111	Attention Seamount	BT	08/10/2022 17:43	-11.7568	103.2803	1408	08/10/2022 18:05	-11.7723	103.2882	1401
	IN2022_v08	113	Lucia Seamount	BT	09/10/2022 7:40	-10.999	102.3823	1968	09/10/2022 8:11	-11.0001	102.3985	1936
	IN2022_v08	115	Scrooge Seamount	BT	10/10/2022 11:54	-10.8958	99.7663	2973	10/10/2022 12:47	-10.8726	99.7771	2974
	IN2022_v08	116	Scrooge Seamount	BT	10/10/2022 18:29	-10.7909	99.6108	1991	10/10/2022 19:43	-10.7998	99.63	1957
	IN2022_v08	117	Rudist Seamount	BT	11/10/2022 5:26	-11.3187	99.1327	1175	11/10/2022 6:12	-11.3077	99.1521	1764

Survey	Op	Locality	Gear	On Bottom				Off Bottom			
				Date (UTC)	Latitude	Longitude	Depth	Date (UTC)	Latitude	Longitude	Depth
IN2022_v08	120	Rudist Seamount	BT	11/10/2022 18:39	-11.0631	99.4434	3839	11/10/2022 20:04	-11.0641	99.4869	3780
IN2022_v08	122	Investigator Ridge Abyssal	BT	12/10/2022 15:33	-11.2571	97.969	4980	12/10/2022 16:27	-11.2579	97.9926	4990
IN2022_v08	124	Cocos (Keeling)	BT	13/10/2022 11:52	-11.8584	96.7403	1020	13/10/2022 12:13	-11.8582	96.7515	967
IN2022_v08	126	Cocos (Keeling)	BT	13/10/2022 19:14	-11.7915	96.8406	820	13/10/2022 19:55	-11.7917	96.8591	822
IN2022_v08	128	Cocos (Keeling)	BT	14/10/2022 6:08	-11.8551	96.786	404	14/10/2022 6:17	-11.8576	96.7901	328
IN2022_v08	131	Cocos (Keeling)	BT	14/10/2022 15:44	-11.8322	96.6267	1896	14/10/2022 16:34	-11.8437	96.6489	1589
IN2022_v08	134	Cocos (Keeling)	EBS	15/10/2022 12:50	-11.9729	96.8136	353	15/10/2022 12:55	-11.9768	96.8178	356
IN2022_v08	136	Cocos (Keeling)	BT	15/10/2022 18:20	-12.0193	96.8365	754	15/10/2022 18:52	-12.026	96.8534	890
IN2022_v08	138	Cocos (Keeling)	BT	16/10/2022 7:11	-12.0468	96.8309	674	16/10/2022 7:23	-12.05	96.8377	648
IN2022_v08	141	Cocos (Keeling)	BT	16/10/2022 13:56	-12.128	96.98	1139	16/10/2022 14:17	-12.133	96.9892	1110
IN2022_v08	143	Cocos (Keeling)	BT	16/10/2022 19:56	-12.2254	96.9599	1113	16/10/2022 20:41	-12.2392	96.9711	1343
IN2022_v08	145	Cocos (Keeling)	BT	17/10/2022 9:31	-12.1265	96.6832	3078	17/10/2022 10:02	-12.1303	96.6774	3002
IN2022_v08	147	Noel Seamount	BT	18/10/2022 6:01	-12.3877	95.3945	2617	18/10/2022 6:40	-12.3954	95.4099	2721
IN2022_v08	149	Noel Seamount	BT	18/10/2022 13:16	-12.5815	95.4183	1904	18/10/2022 13:46	-12.5891	95.4311	1874
IN2022_v08	151	Raitt Ridge North	BT	19/10/2022 0:09	-12.9575	95.4699	3053	19/10/2022 1:10	-12.975	95.4874	3144
IN2022_v08	153	Raitt Ridge North	BT	19/10/2022 8:26	-13.181	95.6007	1736	19/10/2022 9:11	-13.1887	95.6173	1747
IN2022_v08	155	Muirfield Seamount	BT	20/10/2022 4:19	-13.2779	96.0683	1459	20/10/2022 5:03	-13.2831	96.0859	1595
IN2022_v08	157	Muirfield Seamount	BT	20/10/2022 9:04	-13.2437	96.0813	1023	20/10/2022 9:44	-13.2607	96.0988	1019
IN2022_v08	159	Muirfield Seamount	BT	20/10/2022 19:02	-13.1736	96.261	603	20/10/2022 19:35	-13.1827	96.2739	675
IN2022_v08	161	Muirfield Seamount	BT	21/10/2022 1:46	-13.221	96.1114	811	21/10/2022 2:26	-13.2277	96.1258	808
IN2022_v08	163	Muirfield Seamount	BT	21/10/2022 8:44	-13.1744	96.2373	528	21/10/2022 9:23	-13.1807	96.2507	527
IN2022_v08	165	Muirfield Seamount	BT	21/10/2022 14:36	-13.2424	96.2921	932	21/10/2022 15:12	-13.2523	96.3029	965
IN2022_v08	167	Muirfield Seamount	BT	21/10/2022 22:00	-13.212	96.2416	625	21/10/2022 22:42	-13.2226	96.2564	686
IN2022_v08	170	Muirfield Seamount	EBS	22/10/2022 8:16	-13.1683	96.1872	271	22/10/2022 8:27	-13.1741	96.1902	311
IN2022_v08	172	Muirfield Seamount	EBS	22/10/2022 10:38	-13.1684	96.1715	176	22/10/2022 11:02	-13.1681	96.179	169
IN2022_v08	176	Muirfield Seamount	EBS	22/10/2022 17:27	-13.1871	96.1476	367	22/10/2022 17:41	-13.1934	96.1522	365
IN2022_v08	178	Muirfield Seamount	EBS	22/10/2022 20:00	-13.1852	96.1604	94	22/10/2022 20:16	-13.1893	96.1637	137
IN2022_v08	179	Muirfield Seamount	EBS	22/10/2022 21:26	-13.1847	96.1596	121	22/10/2022 21:39	-13.1886	96.1634	111
IN2022_v08	181	Muirfield Seamount	BT	23/10/2022 10:03	-13.0925	96.3524	2923	23/10/2022 10:52	-13.107	96.3627	2889
IN2022_v08	183	Muirfield Seamount	BT	23/10/2022 23:20	-13.4366	96.3048	3948	24/10/2022 0:43	-13.4516	96.3264	4047
IN2022_v08	185	Raitt Ridge North	BT	24/10/2022 14:34	-13.4365	95.8312	1913	24/10/2022 15:19	-13.445	95.848	1950
IN2022_v08	187	Santa Ridge	BT	25/10/2022 2:54	-13.5617	96.3683	2418	25/10/2022 3:19	-13.5529	96.3821	2156
IN2022_v08	189	Santa Ridge	BT	25/10/2022 9:39	-13.7222	96.4681	1943	25/10/2022 10:20	-13.7233	96.4817	1872
IN2022_v08	191	Santa Ridge	BT	25/10/2022 16:04	-13.6519	96.6985	1304	25/10/2022 16:39	-13.6633	96.7114	1325
IN2022_v08	193	SW Cocos	BT	26/10/2022 13:23	-14.7354	95.4172	477	26/10/2022 13:49	-14.7468	95.4225	467
IN2022_v08	195	SW Cocos	BT	26/10/2022 19:46	-14.7906	95.6831	1450	26/10/2022 20:13	-14.8022	95.6897	1426
IN2022_v08	196	Cocos Abyssal	BT	27/10/2022 2:24	-14.9525	95.9171	5414	27/10/2022 3:32	-14.9709	95.9415	3431